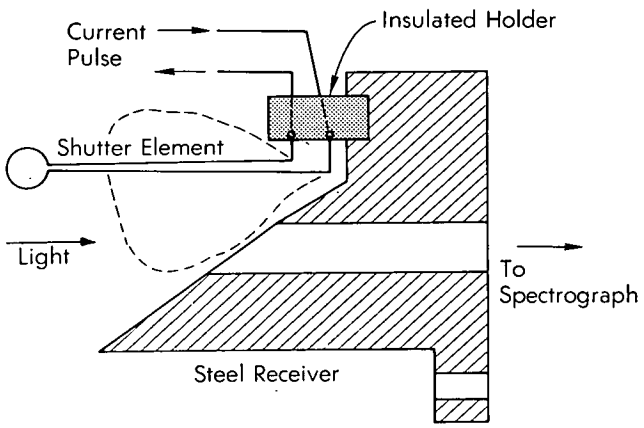
NASA TECH BRIEF

Ames Research Center

Optical Shutter for Use in Shock Tubes

The problem:

To isolate a spectrograph from a high speed shock tube both optically and mechanically so that neither radiation nor particulate material can enter the spectrograph; the shutter must close in less than 100 microseconds after a trigger pulse.



The solution:

A thin metal shutter that is forced into an angled optical slit.

How it's done:

Three types of devices have been used in the past to effect rapid closure of the optical path of spectrograph. One utilizes an electrically ignited powder charge to move a small gate into the optical path of the instrument. The second type uses a thin wire which is vaporized by a pulse of electric current; the shock wave produced by the explosion of the wire pushes a thin foil into the path of the light beam. The third type utilizes the force of the electromagnetic field produced by a current pulse to move a conductor into the optical axis of the spectrograph.

The first type is in general use, but the presence of an unignited powder charge is a continual hazard. More importantly, however, both the first and second types are limited in speed of action because when force is applied to the movable element by a powder charge or through some intermediary material, it can never be made uniform and, therefore, the force that may be applied is limited by shear stress in the moving part. Consequently, the closure speed for these devices can seldom be less than 100 microseconds.

The third type, in principle, has the advantage of higher speed of operation because the applied force acts directly on the movable shutter itself instead of on an intermediary material. Since the electric current is distributed very uniformly through the conductive material of the shutter, a minimum of shear stresses will be developed in the conductor; thus, more force may be applied to metal in this way than in any other way. Unfortunately, the configurations now used cannot be modified to obtain a seal that prevents entry of particulate matter.

The shutter shown diagrammatically is an example of the operating principle of the third type applied in a manner which effects an optical as well as a mechanical seal on the aperture of an instrument such as a spectrograph. The shutter element is made of a thin, soft metal; copper shim stock nominally 0.005 inch in thickness (about 0.13 mm) has been found to be appropriate and readily available. A ribbon of the copper shim stock somewhat wider than the entrance slit to be blocked (about 0.5 cm) is shaped as shown in the diagram and connected to heavy terminals on an insulated holder. The parallel

(continued overleaf)

runs of the conductor are kept close together, usually about 0.25 mm.

When a heavy current pulse is applied to the shutter element, the copper conductor is violently deformed by the interaction of the current and the simultaneous electromagnetic field and is forced into the angled optical slit (as indicated by the dotted lines in the diagram). Because the material is soft, it is forced against the face of the slit and extruded into it; the remaining membrane of metal is an effective seal against positive pressure on one side.

The operation of the shutter has been analyzed, and mathematical expressions for the movement of the shutter as a function of its geometry and physical and electrical properties have been developed. The performances of actual shutters have been measured and the results indicate close conformance with theoretical behavior.

Note:

Requests for additional information may be directed to:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

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